Size of Pollen Grain

The measurements of pollen grains of a group of plants (Table I) showed some differences but were not considered very striking. The shape of pollen grains of all species of both genera were the same and in no particular detail were they found different. There was no correlation between chromosome number and pollen grain size; therefore it is considered impractical to try to determine by pollen grain measurement which are tetraploid and which are diploid forms. Some plants showed high percentage of sterility. *B. notabilis*, a hybrid form from a cross between *B. vulgaris* and *B. heteropoda*, has practically no sterile pollen grains and its parent species show quite a high percentage of sterility. Pollen grains of *B. notabilis* measured 47.5 μ in diameter, while pollen grains of *B. vulgaris* measured 45.1 μ and *B. heteropoda* 50.6 μ, the hybrid having pollen grains intermediate in size.

TABLE I—POLLEN GRAIN MEASUREMENTS AND PERCENTAGE OF STERILITY

Name of species	Size	Sterility %
M. Aquifolium	52.8	65
M. repens	48.4	50
B. diaphana	52.8	4
B. turcomanica integerrima	52.8	10
B. circumserrata	55	nil
B. Gagnepainii	59.4	30
B. verruculosa	57.2	1
B. Vernae	41.8	5
B. brachypoda	50.6	5
B. laxiflora var.	48.4	40
B. vulgaris	45.1	20
B. heteropoda	50.6	12
B. notabilis	47.5	1
B. provincialis serrata	44	30
B. Tischleri (flowers in three)	55	20
" " (flowers in cluster)	46.2	15
B. Julianae	50.6	7
B. Sargentiana	48.4	7
B. Sieboldii	52.8	1
B. dasystachya	46.2	3
B. Fendleri	48.4	5

Species and Generic Hybrids

In the Arboretum there are two or three plants of *Mahoberberis Neubertii* that vary from each other somewhat and they all are considered to be hybrids between *M. Aquifolium* and *B. vulgaris.* These hybrids have never been known to develop flowers.

All the above evidence indicates convincingly that these two genera are very closely related. It would not be surprising that if some artificial intergeneric crosses were tried between *Mahonia* and species of *Berberis* other than *B. vulgaris*, it might result in some successful hybrids that would bloom. Some such crosses were made but only one developed fruits with seeds (Table IIa). The failure in others (Table IIb) may have been due to rain that followed pollination. Some of the crosses will be repeated next year with the hope of getting some successful intergeneric hybrids.

The genus *Berberis* has been divided into 15 groups (Rehder 1927) based on group characteristics. In Table III are listed some of the hybrid forms both of *Mahonia* and *Berberis*. The parent species are given with their climatic zone number, the name and region of countries of their native habitat, and the group number to which they belong according to their group characteristics.

This list indicates that in some cases quite divergent forms have been hybridized with apparent success. Mr. Rehder told me that most of these are chance hybrids. It is especially remarkable that some hybrids have been obtained from crosses between evergreen and deciduous species. Mr. Judd, Propagator at the Arnold Arboretum, informed me that *B. verruculosa* and *B. Gagnepainii* cross freely and give rise to many varied hybrids.

Table IIa gives the list of crosses made by the author that produced fruits; however, nothing further can be said about these till the seeds are germinated and plants grown to maturity. Table IIb contains the list of crosses that apparently were unsuccessful. As can be seen crosses were made between very divergent species, especially between evergreen and deciduous forms, as well as bebetween *Mahonia* and *Berberis* species.

Discussion

Although *Berberis* and *Mahonia* are very old genera they have the same chromosome number, and the numerous and widespread species of *Berberis* show no important differences in either chromosome number or chromosome size. The fact that the two genera can be crossed, and that species hybrids are frequently found in *Berberis*, shows that no fundamental change has occurred in the chromosomes of these genera and species. Even the species of *Berberis* from different parts of the world can often be crossed when brought together, even though they must have been separated for very long periods of time.

Since *Mahonia* and *Berberis* have the same number and size of chromosomes and can be crossed, there is some justification for including both of these forms in the same genus.

TABLE IIa—SUCCESSFUL CROSSES

Zone No.	Group No.	Habitat	Species Name ♀	Species Name ♂	Zone No.	Group No.	Habitat
VI ?	5	W. China	B. Tischleri	× B. Henryana	V	12	C. China
V	5	N. W. China	B. circumserrata	× B. notabilis			
V	12	Japan	B. Sieboldii	× B. diaphana	V	5	W. China
V	10	Turkest.	B. heteropoda	× M. Aquifolium	V		B. C. & Ore.
V	10	Turkest.	B. heteropoda	× B. Julianae	VI	4	C. China
			B. notabilis	× B. Thunbergii	V	12	Japan

TABLE IIb—UNSUCCESSFUL CROSSES

Zone No.	Group No.	Habitat	Species Name ♀	Species Name ♂	Zone No.	Group No.	Habitat
V		B. C. to Ore.	M. Aquifolium	× B. Sargentiana	VI ?	4	C. China
V		”	“	× B. Julianae	VI	4	C. China
VI ?	4	C. China	B. Sargentiana[1]	× M. Aquifolium	V		B. C. & Ore.
VI	4	C. China	B. Julianae	× “	“		“
V		B. C. to N. Mex. and Calif.	M. repens	× “	“		“
VI ?	5	W. China	B. Tischleri	× B. Julianae	VI	4	C. China
V	5	N. W. China	B. circumserrata	× B. Vernae	V	9	N. W. China
V	5	W. China	B. diaphana	× B. Sieboldii	V	12	Japan
V	5	W. China	B. Tischleri	× B. Vernae	V	9	N. W. China
“	“	“	“	× B. brachypoda	V	14	C. & N. W. China
V	5	N. W. China	B. circumserrata	× “	“	“	“

[1] *B. Sargentiana* started to form fruits but very soon after shed its fruit, both crossed and non-crossed.

TABLE III—THE LIST OF HYBRIDS (FROM REHDER 1927)

Zone No.	Group No.	Habitat	Parent species		Zone No.	Group No.	Habitat	Hybrid name
V	—	B. C. to Ore.	M. Aquifolium	× M. Fortunei	?	—	China	= M. heterophylla
V	—	B. C. to Ore.	M. Aquifolium	× B. vulgaris	III	15	Eu.	= Mahoberberis Neuberti
VII or VIII	—	Calif., New Mex. & Mex.	M. pinnata	× M. Aquifolium	V	—	B. C. to Ore.	= M. Wagneri
VIII ?	3	Chile	B. Darwinii	× B. empetrifolia	VI	1	S. Amer.	= B. stenophylla
VII ?	4	S. W. China	B. pruinosa	× B. diaphana	V	5	W. China	= B. Vilmorinii
VI to VII	4	C. China	B. Veitchii	× B. vulgaris	III	15	Eur.	= B. Vanfleetii
IV ?	5	Siberia	B. sibirica	× B. vulgaris	III	15	Eur.	= B. emarginata
VI	6	W. China	B. Wilsonae	× B. aggregata	V	6	W. China	= B. rubrostilla
V	7	N. W. Himal.	B. aristata	× B. vulgaris	III	15	Eur.	= B. macracantha
V	10	Turkest.	B. heteropoda	× B. vulgaris	III	15	Eur.	= B. notabilis
V	12	Japan	B. Thunbergii	× B. vulgaris	III	15	Eur.	= B. ottawensis
V	12	N. China, Amurl.	B. ? Poireti[1]	× B. canadensis	V	12	Va. to Ga. and Mo.	= B. durobrivensis
V	12	Caucas.	B. ? chinensis	× B. vulgaris	III	15	Eur.	= B. laxiflora
V	12	Caucas.	B. ? chinensis	× B. amurensis	II	15	N. E. Asia	= B. Meehanii
V	12	Va. to Ga. and Mo.	B. ? canadensis	× B. vulgaris	III	15	Eur.	= B. declinata
V	12	Va. to Ga. and Mo.	B. ? canadensis	× B. Fendleri	VI	12	Colo. to New Mex.	= B. Rehderiana

[1] Species with question mark are the species of which identity cannot be certain.

Species differentiation in *Berberis* is not due to changes in chromosome number or to any fundamental change in chromosome structure or genetic constitution. Most of the differences between species are those which might be attributed to mutation associated with geographic isolation. It is possible, of course, that hybridization between closely related forms has played an important part in causing variation in this genus, but the production of polyploid types or fundamental changes in the chromosome complex, produced by wide species hybridization, has evidently not played an important part in the formation of species in *Berberis*.

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CHROMOSOMES OF SOME HEVEA SPECIES

W. N. Bangham

In the spring of 1929 the writer, while a student at Bussey Institution, Forest Hills, Massachusetts, conducted an investigation of the cytology of some tropical plants. Thirty-four somatic chromosomes were found in the root tips of *Hevea brasiliensis* Muell. Arg. from the New York Botanic Garden. Heusser (1919) had reported 16 chromosomes in the vegetative and 8 in the generative cells.

It is possible that the tree which had furnished the above material was possibly abnormally polyploid in make-up. The investigation has been continued in Sumatra in the laboratory of the Plant Research Department of the Goodyear Rubber Plantations Co. and was extended to three other species of *Hevea* which were obtained from the Algemeen Proef Station der Avros through the courtesy of Dr. Heusser. These other species, *H. Collina* Huber, *H. guianensis* Aubl., and *H. Spruceana* (Benth.) Muell. Arg. were budded on to *H. brasiliensis* stock with very good success. The only meristematic material available, therefore, was the growing point, which in every case gave good division figures. The species *H. guianensis* and *H. collina* were placed by Huber (2) under the subfamily *Euhevea* as they have only one ring of anthers in the staminate column, and the species *H. brasiliensis* and *H. Spruceana* he placed in the sub-family *Bisiphonia* which has two rings of anthers in the column. Root tips of *H. brasiliensis* and growing points of the other species were fixed in Flemming's strong solution. Buds of *H. brasiliensis* were fixed in a solution of two parts alcohol and one part acetic acid and were imbedded in paraffin. Smears were not satisfactory with such small anthers. The material was all stained with gentian violet by Newton's method.

The four species of *Hevea* studied had the same number of chromosomes—34—as the diploid count. This count was verified in the case of *Hevea brasiliensis* by counts made of chromosomes in the pollen mother cells. In these there were 17 chromosomes. Division was quite regular in every case observed, both in the homotypic and the heterotypic division.

The matter of whether or not hybridization takes place among the various species of *Hevea* has led to much discussion. T. F. C. (3) has stated that: "Experience has shown that cross-fertilization between *H. confusa* and *H. brasiliensis* readily takes place."

While the chromosome count adds no positive information as to whether hybridity has or has not taken place, the fact that all species investigated contain the same haploid number would suggest that fertile hybrids might be formed in some cases. It is evident that the haploid chromosome complement is quite stable.

I wish to express my indebtedness to Dr. Heusser of the Algemeen Proef Station der AVROS for material, and to Dr. J. R. Weir, Director of the Plant Research Department of the Goodyear Rubber Plantations Company for assistance.

SUMMARY

A study of the chromosomes of *Hevea brasiliensis* Muell. Arg., *H. collina* Huber, *H. guianensis* Aubl., and *H. Spruceana* (Benth.) Muell. Arg. has revealed a diploid count of 34 in every case, and a haploid number of 17 in *H. brasiliensis*.

While no direct evidence of hybridity between species is offered, the possibility of fertile hybrids is indicated.

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SUMATRA

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